Exploring spatial allocation techniques for the placement of food pantries: Madison County, Indiana

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In the end I wish my little piece of research proves beneficial to the society.

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Introduction

Food loss is a pressing problem before us. A huge amount of food, 97% of 33.79 million tons, went to the landfills in America in 2010 as waste, which could fill almost 91 Empire State Buildings, a sizable-16 increase from the Figures of a decade ago.(facethefactsusa.org,George Washington University). Roughly 1.3 billion dollars is estimated to cost in the disposal of this colossal food waste to landfills. These sites produce methane, a gas much more effective than carbon dioxide in causing global warming. It is also flammable, which when accumulated can result in a hazard. When water from the rains or flood enters the landfill sites, it creates a liquid called Leachate which pollutes both, water and land as it is highly toxic.

Food insecurity is a challenging issue of our times. The United States Department of Agriculture (USDA, 2016) defines food insecurity "as a state in which constant access to adequate food is limited by lack of money and other resources at times during the year". Based on a large body of research documents, Wight (Wight V, 2014) has observed that the basic reason of food insecurity is low income. With limited income, households are constrained to make difficult decisions that can restrict adequate supply of food (Wight, 2014). These individuals hardly have capacity to own a car. About 26% of low income households lack cars as compared to only 4% of other households. They are severely constrained-to meet the monthly expenses on car installments, car insurance, and gas bills (Elaine Murakami, Jennifer Young, 1997). A sizable section of these households suffer grievously from inadequate food availability. In Madison County, Indiana, food insecure households make 16 % of the total population. Hence there is a grave need to find a solution that reduces food insecurity among deprived households. The task is to enhance free food availability at the most accessible distance by also tackling the problem of food waste.

Purpose of Study

This paper will attempt an exhaustive analysis of existing 17 non optimized food pantries in Madison County and compare it with 17 optimized food pantries such that it helps in reducing food loss within a mile of walkable distance from the food insecure population. Location optimization techniques are capable of increasing the efficiency and optimum placement of different types of services within a community that has localized needs. Hence, they have been used in a wide variety of fields like healthcare, transport but have been used less in the nonprofit sector.

Background

- ***Study Area: Madison County***

It is located in the northeastern part of the central counties of Indiana as depicted by Figure 1. It has a seemingly high food insecurity rate of 16 % meaning 21,020 people are not able to purchase their basic food intake. Poverty rate is also high such that 47% populations are above 185%poverty level and are in need of charitable food. Despite the poor socioeconomic indicators, the whole county is served by just 17 food pantries where as its neighbor Marion County having the same socio economic indicators is served by more than 200 food pantries. **(Gondola, Hunger in Central Indiana, 2014)**

Location of Madison County

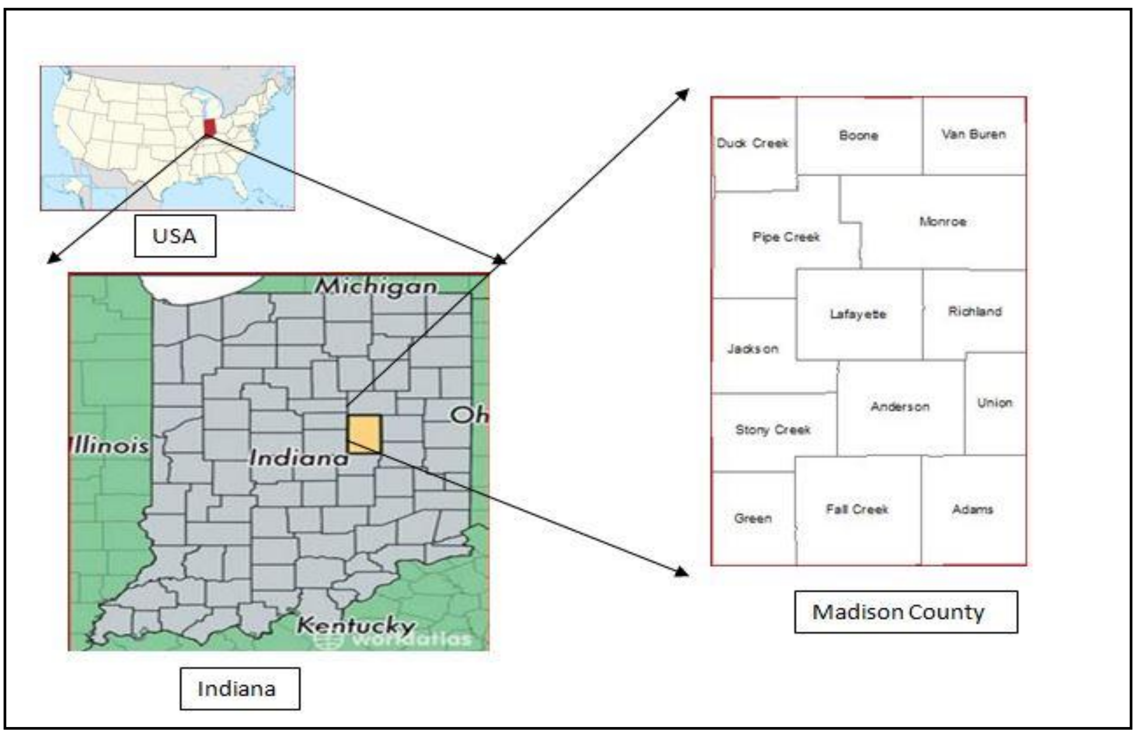
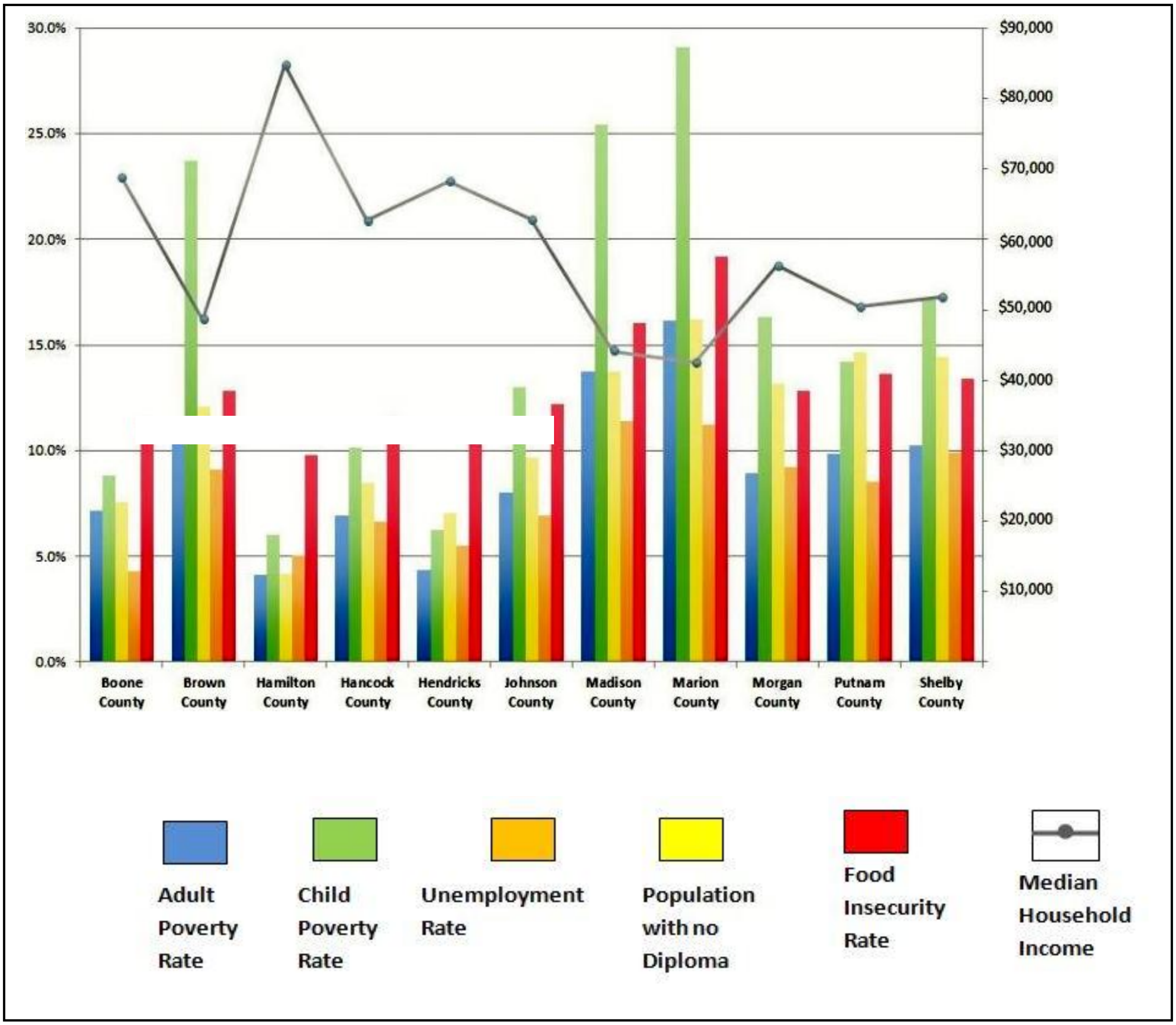


Figure 1

Demographic Profile of Central Indiana Counties



Graph by Indiana University Polis Centre

Figure 2

Looking at Figure 2, we can see that there is little difference in percentages between Marion and Madison counties in terms of unemployment, food insecurity, poverty and population with no diplomas. Madison County's child poverty rate is 4 percent lower and adult poverty rate is 2 percent lower than the highest poverty rate found in the Marion County. The Median household income is the lowest and the unemployment rate is the highest amongst all the counties in Central Indiana. The food insecurity rate is just 3 percent lower than the highest found in Marion County which is 19 percent. Despite such strikingly high rates, Madison County is served by merely 17 food pantries where as Marion county is served by 207.

- ***Food Insecurity***

"When we think of food insecurity, we think of poverty. Where there is poverty there will almost be food insecurity. The numbers of people who need food are much higher than we think". (Arnold, 2004).Thus food insecurity has a direct relation with poverty. Sometimes individuals or households have to make a choice between food and other necessities like payment of utility bills, house rent or medical insurance. Such individuals or households who sacrifice food for other necessities are termed as food insecure individuals or households.

- ***Poverty***

"In Indiana, the city of Anderson (Madison County) and Indianapolis (Marion County) are two of the most densely populated areas in Central Indiana that also have the highest poverty rates. Even though Indiana's disadvantages are well taken care of by the Supplemental Nutrition Assistance Program or SNAP (formerly food stamps) and other federal programs, the reality is that this funding, along with assistance from charitable agencies still does not meet many household's food needs. Many families face the dilemma of choosing between food and other necessities. *Feeding Indiana's hungry clients* survey points out the fact that 46% indicated they had to choose at least once between paying for food or paying utility bills, 36% chose between paying for food or paying for medication or medical care, and 42% chose between buying food and paying the rent or mortgage". (Gondola, Hunger in Central Indiana, 2014).

- ***Accessibility***

It is a prime concern that many poverty stricken families are dependent on public transport or walking as they find it difficult to own a car. In such a scenario, it becomes necessary for food pantries to be located at a distance accessible to such households "Walking distance was calculated because a high proportion of food pantry clients do not own cars or have only daytime access to vehicles like buses. An approximate 15-minute walk, or 0.8 km, is a distance proposed as the maximum that a pedestrian would be willing to travel to nearby stores to obtain groceries." (Algert, Agrawal, Douglas, & Lewis, 2006). "The walk ability range is categorized as either 1) high, if a supermarket is within a half mile; 2) medium, if a supermarket is between ½ and 1 mile; and 3) low, if the nearest supermarket is more than a mile away." (Ploeg, June 2009).Since my study deals with the walk able distance of the target population to the food pantry, hence I replace supermarket with food pantries.

- ***Non Saleable food***

Non Saleable food is generated mainly in the manufacturing and retail sector. "Mistakes during production may result in food that is perfectly safe and edible, but unable to be sold because of quality, overproduction, or labeling issues. The outer packaging of grocery items may become damaged during distribution and retail operations, thus making them unsuitable for sale but still perfectly safe to eat. Fresh food such as day-old bread, produce with blemishes, prepared foods, misshapen vegetables and other perishable items that are near sell-by dates may also be unsuitable for sale, but safe for consumption."(Food Waste Reduction Alliance, 2014).Such edible food if rescued from the food loss generation sites like restaurants,foodstores and institutional canteens can be of great help to the food pantries which disseminate the food to the food insecure individuals ,free of cost.

- ***Laws regarding Donation***

There are certain laws that encourage food donation and help donors from criminal and civil liabilities. The laws are as follows:

"Bill Emerson Good Samaritan Food Donation Act, encourages donation to nonprofit organizations and protects the donor from liability issues like illness as long as the donor has not acted with negligence or intentional misconduct."

"Internal Revenue Code 170(e)(3) also encourages donation of edible food to nonprofit organization. It gives the businesses some amount of tax deductions. "

"The U.S. Federal Food Donation Act of 2008 gives procurement contract and encourages Federal agencies to donate excess edible food to nonprofit organizations." (USDA, 2016)

- ***Rescued food***

Rescued food deals with the simultaneous problem of food waste and food insecurity involving millions tones of surplus food produced that usually goes into the landfill sites instead of feeding the hungry, vulnerable and the disadvantaged people. Mapping will allow concentrations of waste generators to be identified and food pantries to be located close to the source to keep this waste out of landfills. The planning of such large scale food recovery and distribution network as well as its management and optimization is of crucial importance to society. Time has come that humanitarian relief organization and other nonprofit organizations have to use such methodologies where handling uncertainties is critical.

- ***Location Allocation Model***

Operational Research was developed by military planners during World War 1. This technique expanded into other sectors after World War II. It consists of advanced analytical methods like mathematical modeling, statistical analysis, computer science and mathematical optimization to help make better decisions. Facility location is a sub-discipline of Operational Research which is concerned with the optimal placement of facilities that helps to reduce various costs. The cost can be with respect to distance, time etc. Location Allocation has been used in many studies to find the optimal location of different types of services. The paper *"Disparities in access to fresh produce in low-income neighborhoods in Los Angeles"* (Algert, Agrawal, Douglas, & Lewis, 2006) examines the location of the food pantry clients and delineates clusters that are not within the acceptable walking distance of stores that carry fresh produce. The hot spot analysis uses spatial autocorrelation to distinguish between high and low density clusters. Then a delivery route for mobile van (carrying fresh produce to high density clusters) is generated via vehicle routing algorithm in Arc map. Another study titled, "*Assessing the spatial distribution of urban parks using GIS"* (Oh & Jeong, 2007) also applies network analysis on pedestrian data with underpasses, overpasses and bridges based on time. It also calculates the service area ratio (number of parks within the area) and service population ratio (population served within parks) to see if the urban area has sufficient urban parks. *"Location of Recycling Depots with GIS"* (Valeo, Baetz, & Tsanis, 1998) applied a maximum coverage models with distance constraints to choose the optimal location for recycling depots. Tewari & Jena in *"High School Location Decision Making in Rural India and Location-Allocation Models* (Tewari & Jena, 1987) applied these models to locate new high schools in the rural areas of Karnataka's Bellary district in India. The goal of using this approach is to augment accessibility to maximum users within predefined thresholds of 8 km to maximize the public welfare with equitable services. Another study titled *"Selecting conservation reserves using species-covering models*" (Gerrard, Church, David, & Frank, 1997) applies the Maximal Covering Location Problem (MCLP) to locate reserves for endangered plant and animal species in southwestern California. This study's objective is to select the optimal reserves sites that can protect threatened species from the extinction. I believe optimization technique will really prove useful in selecting 17 optimal sites for food pantries that are at a walkable distance from the food insecure population, which will substantially help in reducing food loss.

Study

- ***Design***

This study uses a mathematical approach to solve the facility location model. Transcad uses a heuristic algorithm formulated by Teitz and Bart in 1968. TransCAD will also provide a model for applying a network band to each food pantry location within the network. The hardware utilized for this study is a PC with following specifications: Intel i5-Processor with an 8.00 GB of Memory. The specification is provided because different hardwares take different computation time to run the facility location and the network band model.

The following hypotheses were developed to guide the analysis of the results of this study:

1. The P-Median model solution will be more efficient in placing food pantries at a walk able distance to the food insecure population
2. The P-median model would help in reducing the food loss by covering more rescued food generation sites so that it can be diverted to the food insecure population.

Data

The equations and the data used in the study are as follows

Tiger line Street File 2006 of Madison county, Indiana -The street file contains 14655 line segments in miles. The file itself was not topologically integrated for the facility location problem, and as a result, the file was converted into a standard geographical file by the TransCAD software. This file format was used to create a network, which is necessary to solve this type of problem. There are 10987 nodes associated with this vector line file. Each node represents a potential location where a food pantry can be placed.

Shape files of U.S. Census Block Groups with socioeconomic data: Madison County, Indiana (2013) - Shape files were downloaded from the U.S. Census website (U. S. Census Bureau, 2014). Later Block groups of Madison County were clipped. 109 block groups were identified in the study area. This was joined with data from ACS (American community survey 2009-13). Population was weighted using 2 parameters, households under poverty and households with non ownership of vehicles. The selected table, B01003, contains the total population for each block. Census code B17017e2 was used to determine income status in the past 12 months below poverty level by households. Census code B25044e3 contains the information about non ownership of vehicle by owner occupied housing unit and census code B25044E10 contains information about non ownership of vehicle by renter occupied housing unit which was added to get total households with non ownership of vehicles.

Population under poverty- It is the Total households under poverty in a block group* Total Population of the block group /Total Households in a block group

Population with non ownership of vehicles -It is the Total housing units with non ownership of vehicles in a block group (both renter + owner occupied housing unit) / Total Population of the block group

Food Insecurity -It is “16% of population of Madison County” (Gondola, Hunger in Central Indiana, 2014)

Demand of Donated food in lbs/day - It is “Population under poverty x 4lbs/day” (Arnold, 2004)

Non-Optimized Food pantry Locations in Madison County, Indiana- Locations were obtained from the website of “Second Harvest Food Bank” report of east central Indiana. Most of them are churches. Figure 4 provides the location of the 17 existing food pantries in Madison County (Second harvest food bank).

Food waste generator data -Data was gathered from each participating site to confirm its industry group and size. Much of the information around business is gathered from the website www.reference.com and statewide reports aid in knowing the number of inmates, residential population, college and school enrollment numbers and formulas were applied to get the total. It was divided by 365 to convert it into in lbs/day. The food rescue sites in Figure 3 depict the places from where the edible rescued food can be gathered and disseminated to the food pantries nearby. The equations is based on the results of a study (Mercer, 2013)

1. *Health Care : Food waste (lbs/yr) = N of beds *3.0 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr*
2. *Hospitals : Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr*

3. *Colleges, Universities, and Independent Preparatory Schools Residential Institutions: Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr*
4. *Non-Residential Institutions (e.g., community colleges): Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr*
5. *Correctional Facilities: Food waste (lbs/yr) = l.0 lb/inmate/day * N of inmates * 365 days/yr*
6. *Supermarkets: Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr*
7. *Restaurants: Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr*

Food Rescue Sites in Madison County Indiana-2013

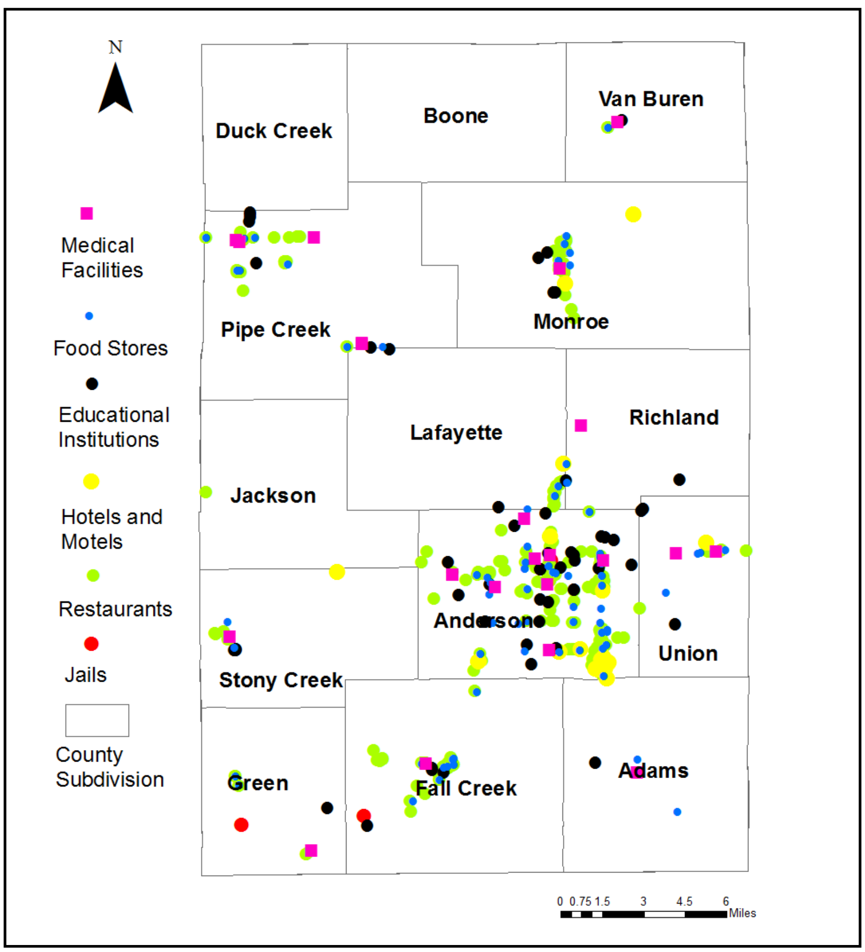


Figure 3

Food Pantries in the Madison County, Indiana-2013

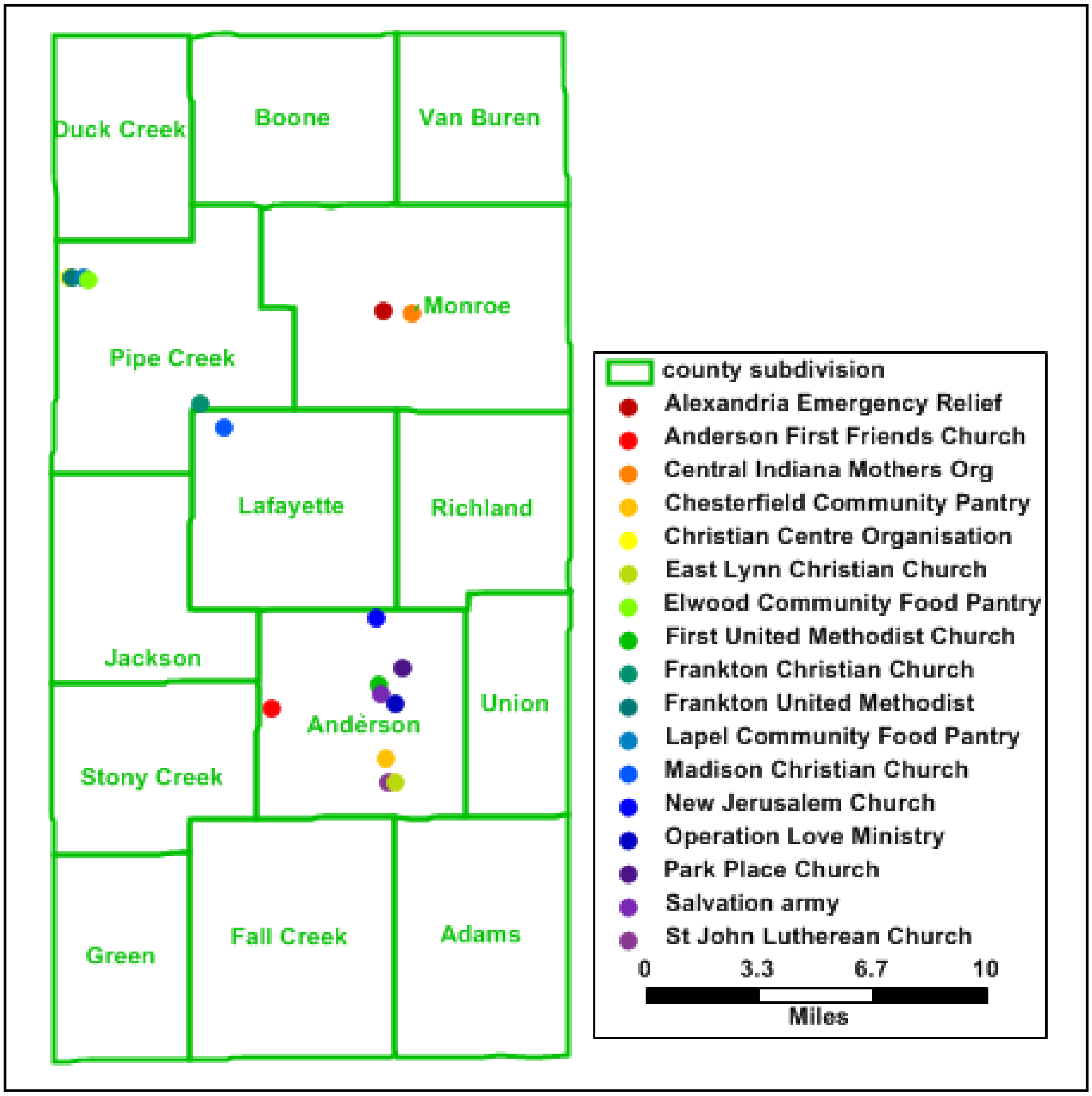


Figure 4

Methods

A number of preliminary steps were required to prepare the data for analysis. The first step involved joining the block group data with the poverty data and population with non ownership of vehicles to the block group shape files based on the block group identification number in each file.

There were further calculations that needed to be done on the data. First, the food insecurity is calculated by taking 16% of the population, since the food insecurity rate of Madison County is 16%. To get the food demand in lbs/day, it is calculated by multiplying the population under food insecurity with 4lbs/day. (John.M.Arnold, 2009)

The Rescued Food generation sites were calculated using the above formula and put into a tabular form as seen in Table 3. Information about the sites was obtained from *reference.com* along with the information on latitude, longitude, number of employees, total students enrolled in educational institutions, total jail inmates. The data collected was for the year 2014.This was then mapped as points using a geocoding tool in ArcGis. An overlay was further applied in TransCad to see the number of food waste generators as well as the amount of rescued food (in lbs/day) that lie within a block group boundary. Figure 5 reveals that maximum food can be rescued from the restaurant which is 38390 lbs/day or 17 tonns/day. Next comes the foodstores with 10528lbs/day followed by hospital canteens.

Next, a Microsoft Excel file containing the names and addresses of the identified 17 food pantry locations was imported into TransCAD 6.0 and geocoded. The result was a point file with the following attributes: food pantry name, address, latitude, and longitude. The 17 food pantries were geocoded easily.

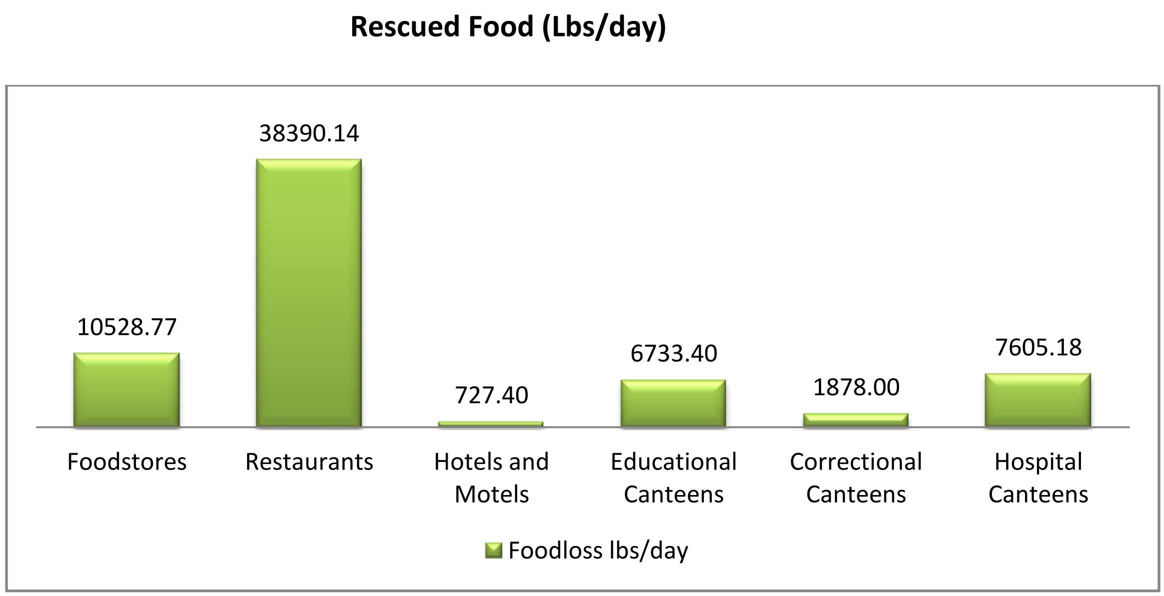


Figure 5

The street network was created with lines and nodes. To avoid duplication of data, and get the value of each node individually, an overlay was done to see total number of nodes that lie within a block group boundary. Variables like household poverty, non-ownership of vehicles, rescued food, donated food demand in lbs/day and food-insecure population were divided by the total number of nodes that lie within the block group. Later the nodes were tagged with the block group data such that each node had a weight of population under poverty and non-ownership of vehicles, food-insecure population, charitable food demand (lbs/day), rescued food loss data in lbs/day. A cost matrix was developed based on the streets (miles) and then a facility location model was applied. A street network based on miles was necessary to reach this goal. The street segments in TransCAD 6.0 did have an attribute indicating the length of the street segment in miles. The street segment is converted into a cost matrix which is a two-dimensional array containing the distances (in miles), taken pair wise, between each node. If there are N elements, this matrix will have size N×N. An excerpt from the cost matrix used in the study is given below.

Distance Matrix 5*5 (in miles)

	10654158	10654159	10654160	10654162	10654163
10654158	0	4.67	4.61	4.56	5.82
10654159	4.67	0	0.08	0.14	1.4
10654160	4.61	0.08	0	0.06	1.32
10654162	4.56	0.14	0.06	0	1.26
10654163	4.82	1.4	1.32	1.26	0

Table 1

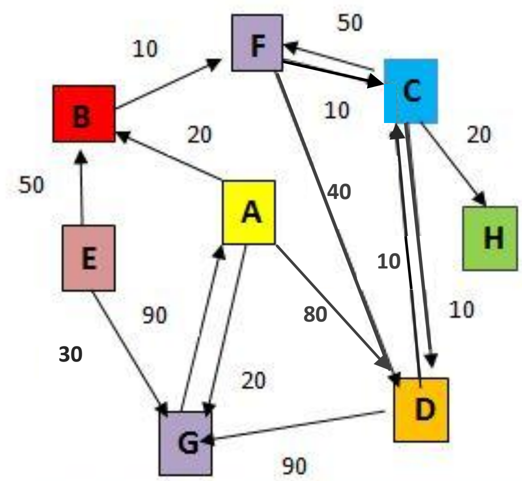
The distance matrix in Table 1 shows an excerpt of the original matrix used in the study. Every intersection point has a distance in miles calculated from all other points like for intersection point 10654158, its minimum distance is from point 100654162 which is 4.56 miles and maximum distance is from point 10654163 that is 5.82 miles.

Using the principles of p-median, an optimal placement of the food pantry is obtained by adopting a mathematical optimization algorithm that utilizes the connections between each node, measuring the length between nodes; the network flows and defines the costs of each potential location. For this study, we chose 17 food pantry locations (facilities) to be determined using the facility location model. All 10987 nodes were used as potential clients in the model out of which 17 locations had to chosen in such a way that each node carried a weight as well as a distance. The node that carried maximum weight and least distance was taken into consideration.

A network band was applied so that the comparison between non-optimized and optimized food pantries can be made. Bands less than 0.5mile is considered highly accessible followed by a medium accessibility band which is 0.5 mile to one mile.

The network is created using Dijkstra's Algorithm of shortest path. Here the connection costs between the street segments is defined by the length of each segment within the network as seen in Figure 6.

Dijkstra's algorithm



From A	B	C	D	E	F	G	H
A	20A	Infinity	80A	Infinity	Infinity	90A	Infinity
B	20A	Infinity	80A	Infinity	30B	90A	Infinity
F	20A	40F	70F	Infinity	30B	90A	60C
C	20A	40F	50C	Infinity	30B	90A	60C
D	20A	40F	50C	Infinity	30B	70D	60C
H	20A	40F	50C	Infinity	30B	70D	60C
G	20A	40F	50C	Infinity	30B	70D	60C
H							

Figure 6

Here the starting node is called the initial node. Let the distance of node Y be the distance from the initial node to Y. Dijkstra's algorithm will assign some initial distance values and will try to improve it step by step. The first paths distance from A was 20, 80 and 90.Out of the three 20 was chosen and B was selected the next vertex. The choices that B had were, 80(from previous), 30(20+10), 90(from previous) . Out of these three, 30 is the shortest path with the next vertex being F. Next F has choices 40(30+10), 70(30+40) and 90(from previous), out of which 40 is the lowest, hence vertex C is chosen. C has choices 50(40+10), 60(40+20) and 90(from previous); out of which 50 is chosen and the next vertex is D. The yellow marked alphabets shows the path with least cost. Hence the least cost path is ABFCD with a value of 60.

10A, 60F, 60C refers to the aggregated distance from the respective vertex. Hence 60C means that the shortest path sums up to 60 from A to H (20+10+10+20).

Determining the placement of food pantry within a street network is closely related to the facility location problem. The example below is a simple version of the model. Suppose if we had to decide a place to open a food pantry out of the 3 places given in Figure 7(A, B or C) such that each point carries a weight. Assume the weights 20, 10 and 7 of A, B, C represent household poverty, non-ownership of vehicles and food loss. The facility model in this case tries to find a best location of food pantry such that maximum households with their respective weights are covered with least distance travelled.

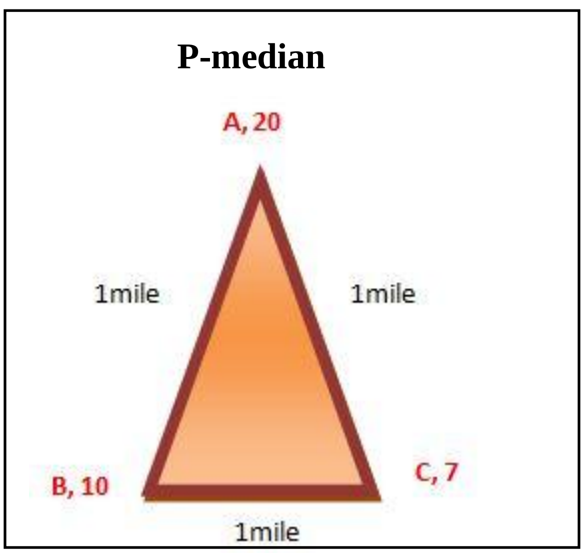


Figure 7

If A, then: 20*0 + 10*1+7*1 = 17 miles walked

B, then: 20*1+10*0+7*1=27miles walked

C, then 20*1+10*1+7*0=30 miles

Hence the food pantry will be located at A since it has the highest weight and it offers least travelled distance compared to other two points B and C. Putting it in a bigger picture with large number of nodes and edges, the number of possible combinations expand in size and is derived by the formula given below.

$$\binom{N}{P} = \frac{N!}{P!(N-P)!}$$

My study area has 10987 nodes. Hence the total combination options available to the computer for locating 17 food pantries is $10987C_{17}$ or more than 12164867387750504484309833272437174792 ways to locate just 17new facilities out of 10987candidate locations. Hence my P-median problem can be solved in polynomial time. The P-median problem becomes difficult to solve optimally with increasing values of N nodes and P sites because some problems require a prohibitive amount of computational time. Those problems are considered NP-hard. NP-hard problems are NP (non deterministic polynomial time) problems. (Daskin, Network and Discrete Location, 2013)

The standard algorithm used in TRASCAD to solve the facility location problem was developed by Teitz and Bart in 1968. It is also known as the exchange algorithm and uses the following methods: (1) select an arbitrary configuration of *P* sites as a solution to the problem, keeping aside the unused p sites in a pool (2) Calculate the shortest path distance between n nodes and *P* sites (3) exchange with a different *P* site from the unused pool set, (4) recalculate the distances between the new *P* sites and *N* nodes, (5) if the distance for the new P sites is shorter than that from the first solution, then the second solution is kept, (6) The process is repeated till there is no unused pair left in the pool that would further reduce the cost. Hence all the possible pair combinations are taken and the best ones are provided by the facility location model.

The network band on the other hand shows which areas within the network would influence a particular location. These are typically generated as a polygon layer, overlaid on the network, indicating bands of travel times or distances. These bands have been generated using distances in miles, with the edge of the band being the upper limit of the distance interval. This proved to be very useful for comparing results between the non-optimized locations and optimized locations.

Results

The following results compare two sets of data; the non-optimized locations and the optimized locations, which were determined using a facility location model. Figure 8 shows the result of the network performed on each set of locations, non optimized and the optimized food pantries. There are 2 distance walkbility bands; one is the high accessibility band (less than 0.5 miles) and medium accessibility band (0.5 to 1 mile).

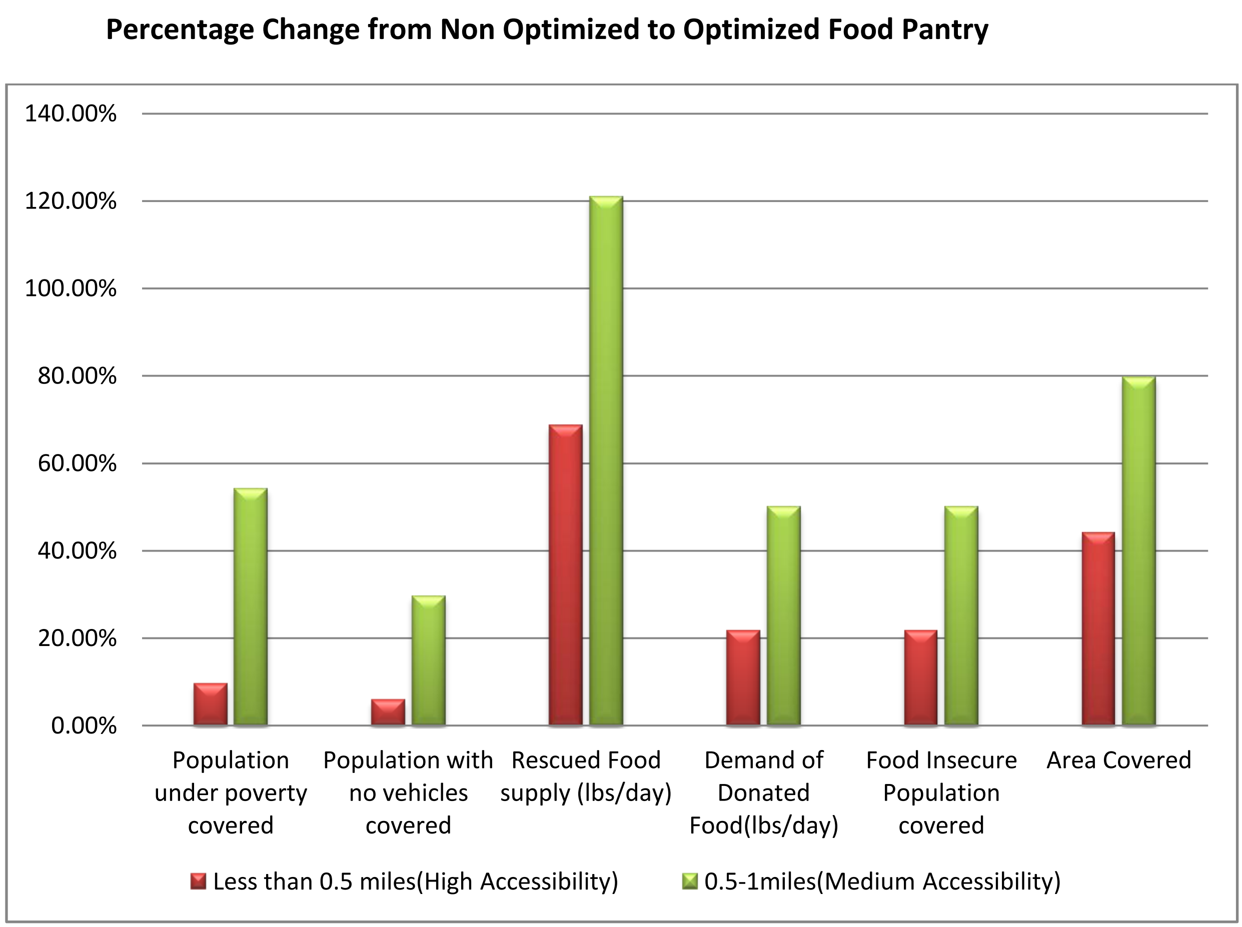


Figure 8

Rescued Food Supply verses Food Demand

Figure 9

- ***High Accessibility (0-0.5miles)***

Looking at Figure 8, there has been an increase in all parameters. Six times more needy people who have no ownership of vehicles are covered by the optimization method. It definitely would be a help for such people to have free food available within half a mile of walkable distance. The optimized food pantry has 65% more recued food available than the non optimized food pantry within just half a mile meaning thereby that there is abundant supply with least transportation cost . Twenty times more food insecure households are covered with optimization model than the existing non optimized food pantries. The food supply increased by approximately 7000lbs/day and demand increased by 400 lbs/day as seen in Figure 9. Therefore the food supply was 6795lbs/day more than the food demand meaning that 1698 more people can be fed per day. The supply of the rescued food exceeds the demand within a 0.5 mile range, which is less than the average walk able distance reducing food loss and hunger both. The non optimized food pantries as seen in the Figure 10 are all clustered together with just a few blocks away from each other like in the cities of Elwood, Frankton and Anderson. Instead of too many food pantries serving an area, the optimized model relocates them in such a way that the food supply from rescued food waste sites meets the demand of food insecure population locally.

- ***Medium Accessibility (0.5 – 1 mile)***

In Figure 8, we see that the bands around the optimized food pantry saw an increase in all the parameters as compared to the non optimized locations. It also reveals that there has been an increase of 79.61% of the area covered by the optimized food pantries along with 55% increase in population under poverty covered and 30% increase in population with non ownership of vehicles covered. Therefore the optimized food pantry covers more poor people for whom walking is the most convenient source of transportation. The average miles that a person is willing to walk are 0.85 miles which also lies within this band. The highest increase has been seen in the supply of rescued food supply which increased by more than 100% as seen in Figure 10. The Food demand covered also doubled compared to the non optimized food pantries. Figure 9 depicts that rescued food supply in the non optimized food pantry was 2126 lbs lesser than the food demand but this increased considerably by 10500 lbs/day feeding an extra 2625 people per day, just by locating it through the optimization model.

Food Insecurity in the past 12 months

MADISON COUNTY, INDIANA-2013

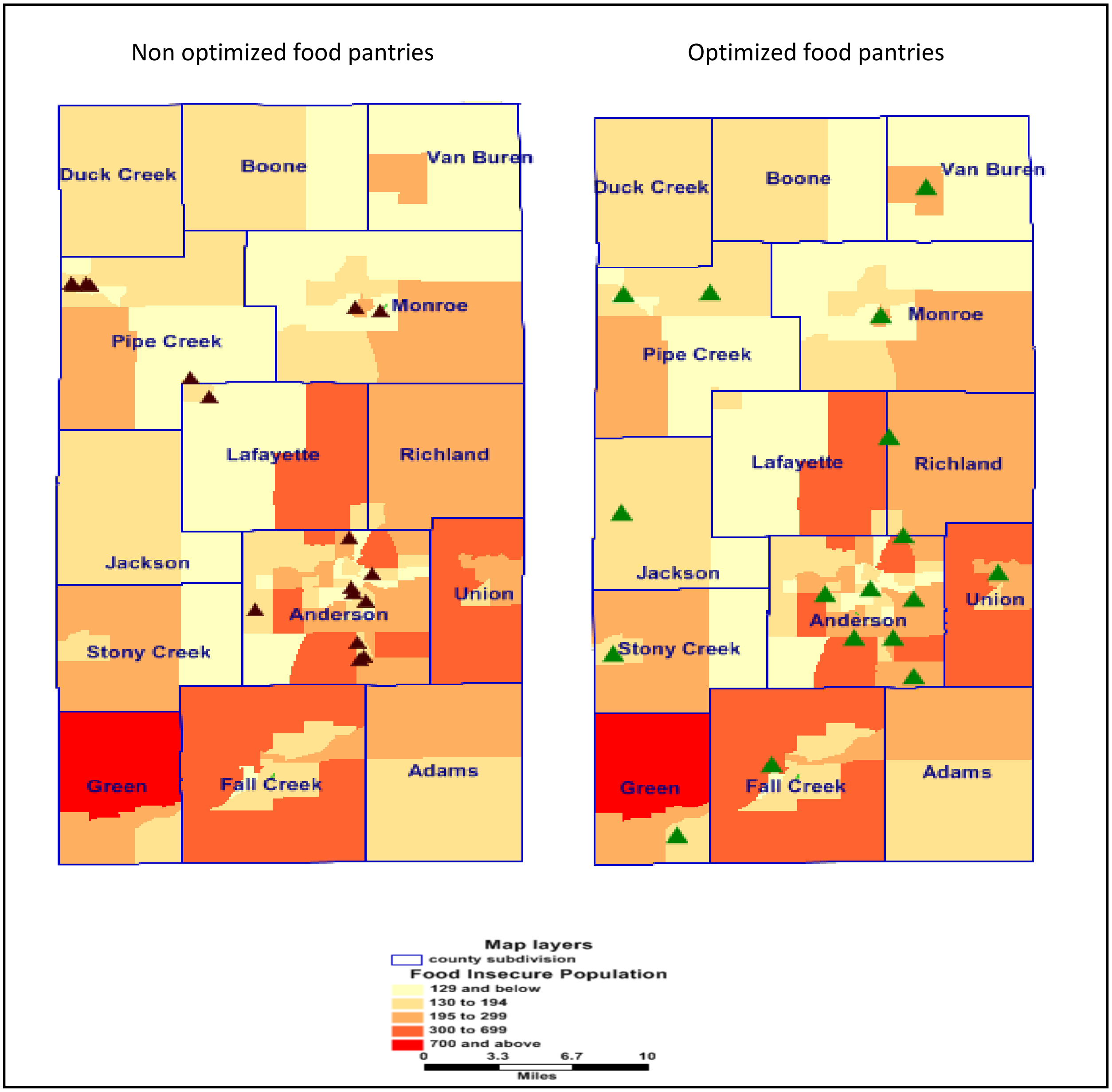


Figure 10

Both the hypotheses proved true in the analysis:

1. ***<u>The P-Median model solution will be more efficient in placing food pantries at a walk able distance to food insecure population and rescued food generation sites</u>:***

As seen in Table 2, the rescued food supply in both, 0-0.5 miles and 0.5-1 miles increased to 70% and 120% respectively as compared to the non optimized food pantries. More food supply means more rescued food sites are covered under the optimized model. The food insecure population covered also increased by 21% in 0-0.5 miles and 50% in 0.5 to 1 miles. There were 6258 food insecure individuals in Madison County and the recued food supply could meet the needs of 9221 people meaning 2971 more people can be fed with the rescued food available. The new food pantries allocated by the P-median model covers more population in need as compared to the non optimized food pantries since they are more dispersed and based on the weight of each node. Therefore the 1st hypothesis is true

2. ***<u>The P-median model would help in increasing the amount of rescued food:</u>***

The optimized food pantry covers more grocery stores, restaurants, hotels and other institutional canteens. Table 2 explains that the increase has been 17516lbs/day of rescued food supply available meaning thereby that it can feed 4379 more people per day as compared to the non optimized food pantry. The increase in the amount of rescued food can be diverted to the food pantries reducing the shortage of food and increasing the choices in food that the pantries often need. This will help in preventing it from going to the landfills thereby reducing food loss. Since such donated food is available within a mile making it makes easier for the food insecure population who usually don’t own a vehicle to get food free of cost. Thus the 2nd hypothesis also stands true.

Analysis of Accessibility Bands

	High Accessibility Less than 0.5 miles	% Change	Medium Accessibility 0.5 miles to 1 miles	% Change
Population below poverty level covered				
Non optimized Food Pantry	2675		3683	
Optimized Food Pantry	2930	9.55%	5679	54.20%
Population with non ownership of Vehicle covered				
Non optimized Food Pantry	1259		1863	
Optimized Food Pantry	1332	5.82%	2415	29.61%
Rescued food (Lbs/day) covered				
Non optimized Food Pantry	10485.13		8695.4	
Optimized Food Pantry	17672.92	68.55%	19211.69	120.94%
Food Demand lbs/day covered				
Non optimized Food Pantry	7247.69		10821.06	
Optimized Food Pantry	8816.44	21.64%	16215.91	49.86%
Food Insecure population covered				
Non optimized Food Pantry	1812		2706	
Optimized Food Pantry	2205	21.64%	4054	49.86%
Area Covered in square miles covered				
Non optimized Food Pantry	5.8		13.78	
Optimized Food Pantry	8.36	44.14%	24.75	79.61%

Table 2

Rescued Food (lbs/day)

Description	Number of facilities	Quantity	Rescued Food in lbs/day
Foodstores			
Supermarkets	41	975	8013.70
Small Grocery Stores	36	306	2515.07
Restaurants			
Full Service	85	1010	8301.37
Limited Service	160	4992	30088.77
Hotels and motels	20	177	727.40
Elementary and secondary schools	36	20547	1418.59
Colleges	5	11859	1228.14
Correctional	3	1878	1878.00
Hospitals	3	399	1364.58
Nursing	42	3467	6240.60
Total	431		7605.18

Table 3

Conclusion

This study explored a facility location model where 17 optimized food pantries were determined and then compared to 17 already existing non optimized food pantry locations. To evaluate changes between the non-optimized locations and optimized locations, a network band was taken and its results were compared.

The new food pantries based on optimization techniques dispersed the 17 food pantries as compared to the clustered non optimized food pantries. It is located at places which covered twice the population under poverty and food insecure households as well as households with no ownership of vehicles. The food pantries become more accessible within a mile of a walk able distance from the households that are poor, food insecure and do not have any personal means of transportation. The optimized food pantries are located at places which have rescued food supply sites like foodstores, restaurants and institutional canteens also within a mile of walk able distance reducing the shortage of donated food that food pantries often face. In this way, extra edible food with myriad choices can be diverted to the food insecure population which can reduce food loss and food insecurity.

Limitations

The following considerations should be explored in future studies. First, the Rescued Food data does not include the rescued food from residential population as a lot of our grocery goes unconsumed which when added may lead to changes in the “donated” food available.

Second, the amount of donated food available in the existing food pantries is also not known. By adding the donated food data to the amount of food supply in the existing food pantries, one can come at an accurate amount of donated food supply available in an area and can also know the amount of food in lbs/day that is required to meet the demand of the area.

Third, population under poverty but owning a vehicle is not taken under consideration which would have changed the data results considerably. A drivable distance under 10 miles is considered highly accessible ((ERS), (FNS), & Cooperative State Research, June 2009).Looking at the map, it appears that the optimized sites happen to be closer to the houses ,hence it means less driving for the poor households with vehicles. An closer study would reveal better analysis.

Fourth, there is a difference in accessibility of the urban and rural areas. The food insecure population in the urban area is more concentrated than in the rural area but rural and urban area is not differentiated in this study. Food insecurity is just not limited to poverty and non ownership of vehicles. Sometimes temporary conditions like unemployment, medical bills, inflation can lead to shortage of food in the house that can add complexity to the study and make it more interesting.

Fifth, certain demographic and environmental characteristics are not taken into consideration like the elderly people, differently abled who have difficulty walking. Certain environment characteristics like snow, rain, extreme weather conditions like tornado are also not considered. Setting up mobile food pantry stops at an appropriate demand time can be another area of study altogether.

Sixth, “time” as a parameter of study is not taken into account. The timings of food pantry, even though at a walking distance might not coincide with the timings of population in need of donated food as some poor people do multiple jobs at odd hours. The network bands measures distance from the households to the food pantry whereas for some people, it would be more convenient to have donated food near the workplace. Also personal choice of food is not taken into study.

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Curriculum Vitae

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Education

MS, Geographic Information Sciences, 2017 – Indiana University, Indianapolis, IN
MA, Geography, 2009- Jamia Millia Islamia, New Delhi, India
BA, Geography, 2004-Aligarh Muslim University, Aligarh, India, Gold medalist

An organized and analytical individual with a passion for environmental Conservation using geographical information analysis. Ability to handle large scale project, both in the public sector and in the private sector. Effective group leader with an expertise in GIS software and applications.

Honors and Awards

As a graduate student at IUPUI, during the course of my MS in GIS, I maintained an overall academic GPA of 3.95 .I have been a gold medalist in my undergraduate career and also qualified NET (National Eligibility test for Lectureship) in India. As an amateur artist, I participated in several posters making competitions and won accolades. One of my paintings on “heritage sites” also appeared in the UNESCO calendar.

Community Involvement:

I volunteer at an orphanage “Bachon ka ghar” in Aligarh, India that provides good quality residential education to the orphans coming from economically deprived homes. Moreover the organization coaches such children for competitive exams in India.